DOCUMENT RESUME

ED 256 333 IR 011 653

AUTHOR Salisbury, David F.
TITLE Using Microcomputers for Drill and Practice: Issues and Implications.
PUB DATE Jan 85
NOTE 16p.; Paper presented at the Annual Convention of the Association for Educational Communications and Technology (Anaheim, CA, January 17-23, 1985). For entire proceedings, see IR 011 621.
PUB TYPE Viewpoints (120) -- Reports - Descriptive (141) -- Speeches/Conference Papers (150)

EDRS PRICE MF01/PC01 Plus Postage.
DESCRIPTORS *Computer Assisted Instruction; *Design Requirements; *Drills (Practice); *Feedback; *Microcomputers; *Models; Research Projects
IDENTIFIERS Corrective Feedback Paradigm; Florida State University; Progressive State Paradigm

ABSTRACT

Issues and implications related to the use of microcomputers for providing practice activities are addressed, including which skills should be automatized, requirements for ensuring that a skill has attained automaticity, scheduling and amount of practice, and the type and use of data that should be collected on individual student practice performance. Two drill and practice programs are described as examples of high quality, sophisticated, computer-based practice strategies. First, the corrective feedback paradigm is identified as adding several features available only in computerized drill, including specialized feedback, discrimination training, spaced review, and the retirement criterion. Then, the Progressive State Paradigm is introduced. This sophisticated drill strategy uses a student's response history to alter the remaining instruction in order to optimize the learning process. The paper concludes with a description of a Florida State University research program designed to identify effective and efficient computer-based drill and practice instructional strategies. Eleven references are listed, and a flowchart illustrates the structure of a progressive state paradigm. (LMM)

****
* Reproductions supplied by EDRS are the best that can be made *
* from the original document. *
****

ED256333

U.S. DEPARTMENT OF EDUCATION
NATIONAL INSTITUTE OF EDUCATION
EDUCATIONAL RESOURCES INFORMATION
CENTER (ERIC)

☒ This document has been reproduced as received from the person or organization originating it.

☐ Minor changes have been made to improve reproduction quality.

• Points of view or opinions stated in this document do not necessarily represent official NIE position or policy.

TITLE: Using Microcomputers for Drill and Practice: Issues and Implications

AUTHOR: David F. Salisbury

IR011653

"PERMISSION TO REPRODUCE THIS MATERIAL HAS BEEN GRANTED BY

Michael Simonson

TO THE EDUCATIONAL RESOURCES INFORMATION CENTER (ERIC)."

Using Microcomputers for Drill and Practice: Issues and Implications[1]

David F. Salisbury
Florida State University

Use of the microcomputer as a means to provide practice drills to learners is regarded by some as not being a creative use of the computer. Computer programs are often criticized for containing too much drill and practice. Apparently, some people feel that it is a shame to use a marvelous device like the computer for "mere" drill and practice, when it could be used for seemingly more creative activities.

In her recently published book, Helm (1984) pointed out the irony involved in criticism by teachers of computer-based drill and practice. It would seem that teachers would welcome a tool to provide individualized practice to students beyond what they themselves are able to provide. Teachers do not typically enjoy conducting drill and practice routines and using the computer to provide this essential activity could conceivable free up teacher time to spend in developing student's higher order cognitive skills.

Part of the reason for the negative view of computer-based drill and practice is probably due to the desire of teachers to pursue seemingly more exciting intellectual activities, therefore, any drill and practice program, no matter how well designed or sophisticated is viewed as undesirable. Much of the negativism, however, is undoubtedly due to the problem of the quality of the drill and practice software currently in the schools. Many computer drill and practice programs

---

[1]Presented at the annual meeting of the Association for Educational Communications and Technology, January 1985, Anaheim, CA.

are admittedly dry, boring, and unpleasant and often ignore some of the most basic principles derived from research in learning psychology. However, these bad examples should not cause us to underestimate potential value of computer-based drill and practice. Practice does not have to be dry and unpleasant. Many kinds of arrangements can be made to make drill and practice an interesting activity.

This paper describes some of the issues and implications related to using the microcomputer as a means to provide practice activities. Also described are two drill and practice programs which exemplify a higher quality and sophistication of computer-based practice strategies. Finally, the paper describes a program of research being conducted at Florida State University to identify effective and efficient computer-based drill and practice instructional strategies.

Automaticity of Subskills

Recent research in modern cognitive learning is suggesting that drill and practice may be more important than many people realize. The research that suggests this is related to the area of automaticity of subskills. Automaticity refers to the state at which a skill ceases to consume much of the attentional capacity of the brain. Usually, an automatized skill can be performed simultaneously with other tasks without interfering with the performance of those tasks. Examples of skills which have become automatic to some people are skills such as typing, discriminating numbers from letters, or decoding common words.

Research is suggesting that in order for learners to perform complex skills such as reading, computer programming, or mathematical problem solving, many of the subprocesses involved have to have become

automatic to the learner. The implications of this research are that certain basic procedures which later become subprocedures to higher order skills ought to be not simply mastered, but brought to a state of automaticity.

As far as we know at the present time, the only way a skill becomes automatic is through an extensive amount of practice, usually extending over a long period of time. Because it is difficult for teachers or trainer to provide sufficient practice to assure that all students automatize important subskills, many prominent researchers are looking to the computer as a means to more efficiently provide the type and amount of practice necessary to produce automaticity (e.g. Gagne, 1982; Lesgold, 1983). However, these researcher have pointed out that computer drills which will effectively help learners automatize skills will probably need to be more sophisticated and better designed that the typical drill and practice programs currently available for microcomputers.

The concept of automaticity also implies that in addition to accuracy of performance, speed, and the ability to perform the skill without interfering with a secondary task are important criteria for determining mastery (Resnick & Ford, 1981, chap. 2). Also implied is the idea that performance could profitably be evaluated and remediated in terms of "bugs" in subskill performance. Brown and Burton (1978) have demonstrated that all errors computed by students are not random errors, but many times are an indication of a bug or a bug combination in one of more of the subprocesses.

In the context of using the computer as a tool for helping students automatize skills several issues arise:

1. Which skills should be automatized?

2. What needs to be done to make certain that a skill has attained the status of automaticity?
3. When should practice be given and how much practice should be given?
4. What kind of data should be collected on individual student practice performance and how should that data be used?

Which Skills Should be Automatized?

Skills which need to be automatized are those which have to be carried out by the student simultaneously with other skills or, as part of a higher level, more complex skill. We know from the work of such researchers as Schneider & Schiffrin (1977), Lesgold & Resnick (1982), and Beck, Perfetti, & McKeown (1982) that many of the basic component skills of reading and math need to be automatized. It is obvious that efficient computer programmers, typists and musicians have all automatized many of the subprocesses which constitute their respective skills. At this point we do not have any way of determining whether a skill needs to become automatic other than looking at a person who performs the higher level skill and trying to determine which subskills that person performs automatically. Task analysis (breaking down a skill into its component parts) should be used as a tool for helping us determine the subskills involved in performance of a higher-order skill.

What Needs to Be Done to Make Certain That a Skill Has Attained the Status of Automaticity?

Automaticity is a fairly new concept and ways to measure it are still forthcoming. At the present time we might establish the policy

of including speed and the ability to perform the skill simultaneously with some other skill as criteria for mastery.

In order to accomplish this, practice drills could be devised to include three stages. The first stage would concentrate on helping the student learn to perform the skill accurately. In the second stage speeded practice would be introduced until performance is both fast and accurate. In the third stage, a competing task or game would be introduced which the student would have to attend to while performing the original task. What we are working for is performance which is not only fast and accurate, but fast, accurate, and automatic.

When Should Practice be Given and How Much is Needed?

There is much evidence in the literature to suggest that short, spaced periods of practice give better results than long concentrated practice sessions (see Anderson, 1980). This spacing effect has repeatedly been shown with many types of material. If the computer is to be used as a tool for developing automaticity it will have to be integrated into the curriculum in such a way that students can space practice of a skill over a period of time in a systematic manner. Some computer drills are designed to be completed by the learner in one sitting. If the learner stops the drill and resumes it later, the learner is required to practice on the same items in the same sequence as before, which is not a good practice strategy.

In order to produce automaticity, what is needed are computer programs which include the capability of allowing the learner to stop and resume practice sessions without starting at the lowest difficulty level of the skill or with the same items as before. In some cases, this can be done by dividing the content into difficulty levels and

allowing the learner to specify the appropriate difficulty level for each practice session. In other cases, this must be done by having the computer keep a record of each individual learner's performance on the drill. This requires that the learner sign on to the drill by name and date so that at the beginning of each new practice session, the computer can retrieve the individual record for that learner.

Because automaticity requires that a skill be overlearned and used over a long period of time, computer drills should be designed to be "practice and review" drills rather than simply practice drills. Once an item or piece of material has been learned, a mechanism should be provided to reintroduce that item or material systematically for review. This can be done by setting up a series of review stages allowing mastered items to be reviewed at different stages, say after a day, then again after a week, then after a month.

Another way to approach this might be to provide "increasing-ratio review" where the amount of review material increases and the amount of new material decreases as more material is covered. When the student first begins the drill, all the items are new items. As the student masters items, these become review items and are reintroduced systematically into the drill. Eventually most of the items the student will be working with will be review items.

As you can see, using the microcomputer in this way would require an integration into the classroom or training curriculum that is different from the typical adjunct use of the microcomputer in the classroom.

What Kind of Data Should be Collected on Individual Student Performance and How Should That Data be Used?

Computer drills could be categorized as being of two types: intelligent and non-intelligent. Intelligent drills would be those which continuously collect data on student performance during the drill and use that data to modify presentation of the drill on an item-by-item basis. Non-intelligent drills would be those which do not collect student performance data and which present the same items to each learner in the same sequence each time.

Using a learner's response history to make instructional decisions and alter the remaining instructional sequence requires the continuous collection of student performance data. It also requires the use of mathematical models to specify optimal sequencing schemes. In designing an intelligent computer drill the question arises of what data to collect and how to use that data to alter the sequence of instruction. Atkinson (1974) has shown how the principles derived from what is referred to in the literature of mathematics and engineering as optimal control theory, or simple control theory can be used to optimize the instructional sequence for a particular learner. The type of data which typically has to be collected includes what items have received correct responses, how many intervening items have been seen, and, for review purposes, how long of a time period has elapsed since an item was seen. The two computer drill strategies described later in this paper demonstrate different approaches to utilizing student performance data to modify the instructional presentation.

Two Good Drill and Practice Strategies

The Corrective Feedback Paradigm

The Corrective Feedback Paradigm (CFP) is a drill and practice strategy which could be used to present drills on paired-associate tasks such as medical terminology, chemicals and their abbreviations, English and foreign language vocabulary, etc. As opposed to the type of drill which could be done by hand with flashcards, the CFP adds several features only available in a computerized drill. Each of these are discussed briefly below.

Specialized Feedback. In learning paired-associated items, two types of errors are possible: 1) out-of-list errors (giving a response which is not an answer to another item in the list), 2) discrimination errors (giving a response which is an answer to another item in the drill list). In the CFP, the type of feedback provided to the learner is a function of the type of mistake made. If the learner makes an out-of-list error, the correct answer is provided; for a discrimination error, the feedback tells the learner what stimulus the student responded to as well as the answer to the stimulus that was actually provided.

Discrimination Training. After committing a discrimination error, the student is given a discrimination training sequence. This involves presenting the item missed and the item with which it was confused. The student must be able to respond correctly to both stimuli before returning to the drill.

Spaced Review. After the student makes a mistake, the missed item reappears according to a spaced review schedule determined by the designer who may specify up to three review positions. For example, a

missed item might appear after 2 intervening items, then again after 6 more items, then a third time after 10 more items. At any stage during the review cycle an incorrect response on a review item reinitializes the review sequence for that item.

Retirement Criterion. Items are retained in the drill until the student responds correctly to an item a specified number of times in a row. This number can be set by the designer of the drill. As items are retired from the drill the number of items the student is working with decreases until all items have been retired.

Because the CFP is a drill template designed to accommodate various content, all of the features of the CFP--feedback messages, spacing of the review, and retirement criterion can be set and manipulated by the designer. The CFP is available on the PLATO instructional computing system and has been used to construct drills in various content areas. Comparisons of the CFP with other drill paradigms show that the CFP is a more effective means of providing training in these types of skills than what could be done by hand without using a computer (Seigal & Misselt, 1984).

The Progressive State Paradigm

The Progressive State Paradigm is a sophisticated drill strategy which uses a student's response history to alter the remaining instruction in order to optimize the learning process for that student. This is done by presenting items in six exercise formats. Optimization of the drill involves deciding which items to present, which exercise formats to present them in, and when to schedule review. This requires a complete response history for each student and use of this history to make trial-by-trial decisions regarding which items to present next.

Figure 1 presents a flowchart (adapted from Atkinson, 1974) showing the structure of the drill and the various exercise formats. When a student begins a practice session, any items left in his or her working pool from the last session are transferred from the disk to the current working pool. If the working pool is not full, then additional items are selected from the review pool if there are any items which have a review date less than or equal to today's date; otherwise additional items are selected from the new item pool. The working pool is then shuffled and the first item is selected from the working pool and its state identified. The item selected may be shown to the learner in any one of six states. If the item has just entered the working pool for the first time, it will be presented as a pretest item (state 1). If the learner responds correctly to the item, it will be deleted from the system. Otherwise, its state will be updated to state 2. The value of the item counter (N) is then incremented, and the second item from the working pool is selected. This item is presented in accordance with its specified state. Note that after an item is presented in state 3, it is removed from the working pool and transferred to the review pool. after all items in the working pool have been presented once (N > 7), the working pool is replenished and shuffled, and the item counter (N) is set back to 1. This process is repeated until the student terminates the practice session.

When an item is presented in the Rehearsal state (state 2), the stimulus and corresponding response are presented to the learner simultaneously to allow the learner to associate them together. The learner is then asked to merely enter a copy of the correct response. In the Drill state (state 3), only the stimulus is presented, and the

learner is asked to enter the correct response. If the item has been answered correctly a sufficient number of times to pass the specified criterion, then it is transferred to the review pool. The review date is set for the appropriate date (generally the next day).

During any of the Review states (states, 4, 5, and 6), only the stimulus is presented, and the learner is asked to enter the correct response. This is identical to how the item is presented in the Drill state. When an item has been answered correctly to the criterion level set for the specific Review state, it is removed from the working pool and transferred back to the Review pool with a new review date.

All of the criterion settings which determine when to move an item from one state to the next as well as the other features of the Progressive State Paradigm (number of items in working pool, spacing between reviews, etc.) can be manipulated by the designer to fit the nature of the application and ability level of the students.

Current Research at Florida State University

At Florida State University we are currently engaged in three programs of research which relate to the design of computer-based drill and practice instructional strategies. The first program of research related to this area seeks to identify guidelines for designing practice drills by drawing from the basic sciences of behavioral and cognitive psychology. Currently, we are attempting to integrate the findings of this literature review into a model or aid for designing computer-based practice strategies.

The second research program attempts to empirically verify the prescriptions and recommendations for designing practice derived from the work described above. In this investigation, microcomputer

technology is used to deliver different practice strategies in order to test the relative effects of these strategies on learning. This program also involves the evaluation of commercially available drill and practice programs for microcomputers in order to categorize them as to effectiveness and to evaluate the degree to which they incorporate the recommendations derived from the literature.

In a third project, the ability to use the computer to develop subskill automaticity is being explored. This project deals with development of skills necessary to efficiently solve mathematical word problems. Theorists have proposed that in order to solve math word problems learners must develop skills in several related subskill areas, the most important of which are keyword recognition, problem type recognition, goal identification, diagramming, basic computation, and answer estimation. As part of this project, computer-based training involving sophisticated drill and practice strategies is being developed to produce automaticity in these skills. This program is serving to provide a unique laboratory for investigating the role and effectiveness of various instructional strategy parameters in producing automaticity. It is hoped that these investigations will provide validated guidelines for the development of efficient and effective computer-based drill and practice instructional programs.

References

Anderson, J. R. (1980). Cognitive psychology and its implications. San Francisco: Freeman.

Atkinson, R. C. (1974). Teaching children to read using a computer. American Psychologist, March, 169-178.

Beck, I. L., Perfetti, C. A., & McKeown, M. G. (1982). The effects of long-term vocabulary instruction on lexical access and reading comprehension. Journal of Educational Psychology, 74, 506-521.

Brown, J. S., & Burton, R. R. (1978). Diagnostic models for procedural bugs in basic mathematical skills. Cognitive Science, 2, 155-192.

Gagne, R. M. (1982, June). Developments in learning psychology: Implications for instructional design; and effects of computer technology on instructional design and development - an interview with Robert M. Gagne. Educational Technology, 11-15.

Helm, V. (1984). Software quality and copyright: Issues in computer-assisted instruction. Washington, DC: Association for Educational Communications and Technology.

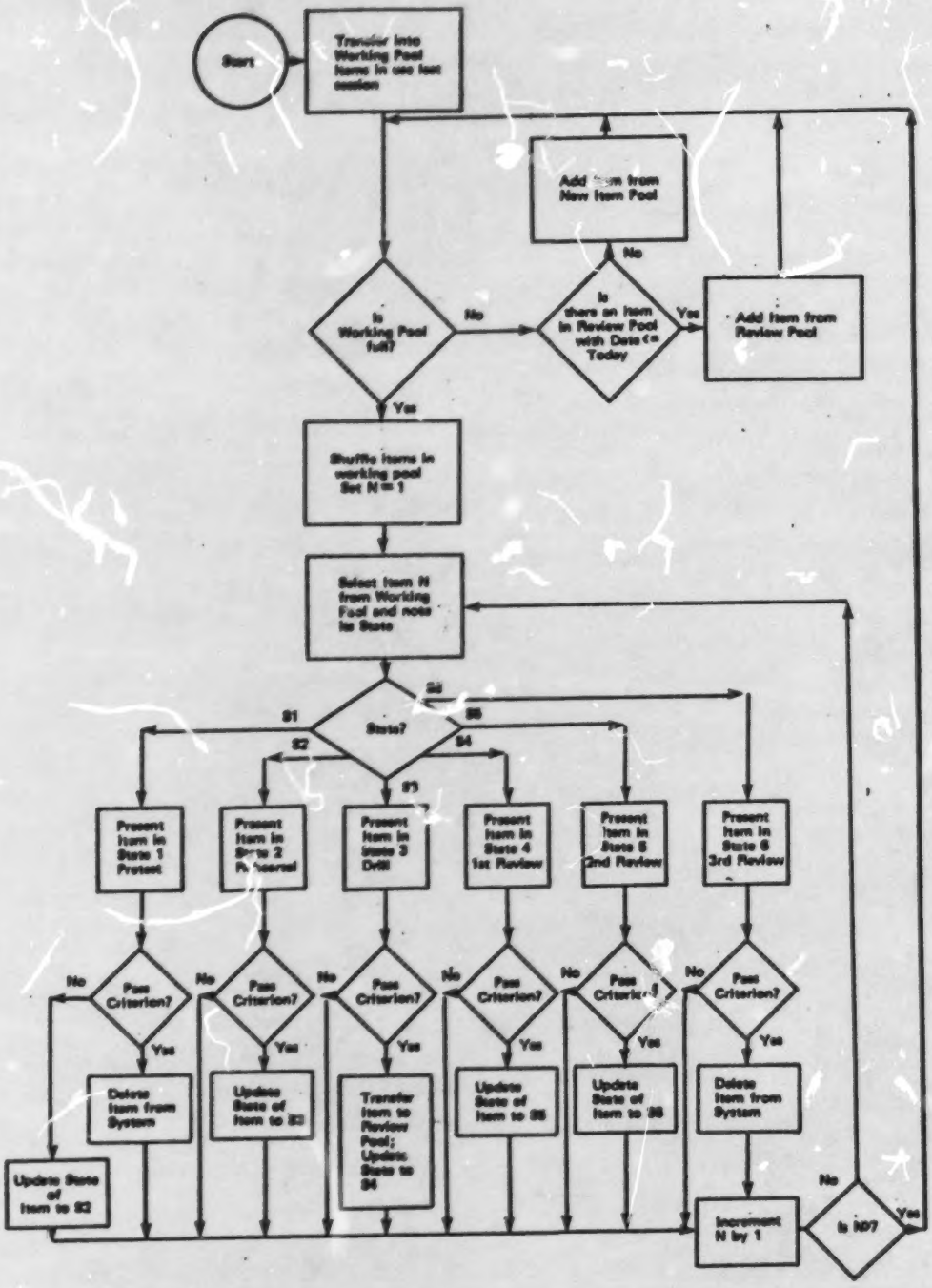
Lesgold, A. M. (1983). A rationale for computer-based reading instruction. In A. C. Wilkinson (Ed.), Classroom computers and cognitive science. New York: Academic Press.

Lesgold, A. M., & Resnick, L. B. (1983). How reading disabilities develop: Perspectives from a longitudinal study. In J. P. Das, R. Mulcahy, & A. E. Wall (Eds.), Theory and research in learning disability. New York: Plenum.

Resnick, L. B., & Ford, W. W. (1981). The psychology of mathematics for instruction. Hillsdale, NJ: Lawrence Erlbaum Associates.

Schneider, W., & Schiffrin, R. M. (1977). Controlled and automatic human information processing: I. Detection, search, and attention. Psychological Review, 84, 1-66.

Siegel, M. A., & Misselt, A. L. (1984). An adaptive feedback and review paradigm for computer-based drills. Journal of Educational Psychology, 76, 310-317.


Start
Transfer into Working Pool items in use last session
Add Item from New Item Pool
No
Is Working Pool full?
No
Is there an item in Review Pool with Date <= Today
Yes
Add Item from Review Pool
Yes
Shuffle items in working pool Set N = 1
Select Item N from Working Pool and note its State
State?
S1
S2
S3
S4
S5
S6
Present Item in State 1 Pretest
Present Item in State 2
Present Item in State 3 Drill
Present Item in State 4 1st Review
Present Item in State 5 2nd Review
Present Item in State 6 3rd Review
Pass Criterion?
No
Yes
Delete Item from System
Update State of Item to S2
Transfer Item to Review Pool; Update State to S4
Update State of Item to S5
Update State of Item to S6
Increment N by 1
Is N=7
No
Yes

Flowchart showing the structure of a progressive state paradigm (adapted from Atkinson, 1974).

BEST COPY AVAILABLE